A New Portable Clinical Suction Device

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Effective aspiration of the airway under conditions of emergency care can be difficult. The need for rapidity, the natural tendency for human error in emergencies, unsatisfactory patient position, lack of assistance, and the mechanical inadequacy of portable suction devices all contribute to the problem.

Proper equipment design incorporating good mechanical and technical characteristics can be supplemented by good human engineering to enhance efficiency of use decreasing the probability of error and the need for assistance. Rosen and Hillar have characterized the ideal clinical suction apparatus. A minimum vacuum of 25 in/Hg, free air flow of 25-30 l/min, and rapid drawdown time to maximum vacuum to decrease the time required for adequate suctioning are desirable.1

Currently available equipment fails, for the most part, to attain these goals. Four basic types of portable aspirators are in use today. The suction bulb, while inexpensive and reliable, creates insufficient vacuum and will not remove viscid secretions or adequate volume. Electrically powered rotary aspirators provide adequate suction but require large heavy-battery-powered packs, or frequently overload already-burdened ambulance electrical systems. The commonly used AMBU foot-powered unit is awkward for a single operator to use and provides only 11 in/Hg suction. Gas-powered Venturi aspirators of the type so frequently incorporated in resuscitation apparatus for use in the hospitals, ambulances, aid stations and the field not only waste oxygen but also do not provide adequate suction. One commonly used portable unit can attain only 4 in/Hg. Such devices are notoriously ineffective in removing significant amounts of viscid material or vomitus from the airway.

DESCRIPTION

A new device † has been developed to meet the need for a lightweight portable suction apparatus. It is able to exceed 25 in/Hg vacuum, contains no moving parts, is modest in its consumption of compressed gas or oxygen, and has proved reliable and easy to use. It was designed specifically for portable resuscitation kits, litters, ambulances, and emergency lifesupport and resuscitation carts. It also has general use within the hospital, emergency room and intensive care unit, and may be used in hazardous locations where electric motors might be dangerous. This apparatus is especially useful on litters, when it is desirable to have suction immediately available for postoperative patients in transit.

In a typical configuration for use on resuscitation carts or within the hospital, a block containing the air ejector and vacuum gauge is attached to a heavy aluminum chassis which also holds the collection bottle, hose and pistol grip with trigger control. The instinctively handled pistol grip and trigger control of this suction device encourage rapid, effective aspiration during clinical emergencies.

The basic apparatus is a one-stage air ejector powered by compressed gas with an input pressure which may vary from 40 to 75 psig. Maximum performance is attained with pressures approximating 50 psig. This pressure value is provided by the vast majority of hospital wall oxygen systems and most resuscitator regulators. The air ejector is connected to a 500-ml collection bottle equipped with an overflow valve to prevent suctioned material from passing into the air ejector. Should debris inadvertently enter the ejector, the mechanism...
tends to be self-purging and, in addition, is easily cleaned.

The suction tubing leads from the collection bottle to the pistol grip, into which the off-on and suction controls are incorporated. Squeezing the trigger supplies oxygen or other compressed gas from the primary source to the air ejector. The amount of vacuum created, from 0 to 27 in/Hg, depends on the pressure exerted on the trigger by the operator. A tapered nozzle, representing the barrel of the pistol, may be used as the oropharyngeal suction tip or will accept a standard catheter for deep suction. Releasing the trigger immediately causes the vacuum to drop to zero in the same manner as removing one's thumb from the T or Y connector between tubing and catheter of a conventional aspirator. Intermittent suction or release of caught tissue thus is controlled easily. The pistol grip provides single-handed control of the off-on trigger, degree of vacuum desired, and manipulation of the suction nozzle or catheter. This permits the other hand to be used for positioning the patient or fine manipulation of a deep suction catheter.

The very rapid increase in vacuum permits insertion of the suction tip or catheter with the apparatus shut off. Oxygen is consumed only during the actual period of suctioning and not during handling or inserting the catheter. This results in great reduction of gas consumption, a matter of importance in ambulances and portable resuscitation kits which carry limited supplies of bottled oxygen.

Quick connect-disconnect fittings permit rapid removal and assembly of the clear polyvinylchloride oxygen tubing. The clear polyvinylchloride aspiration tubing itself snaps into the pistol grip and may be easily cleaned or discarded and replaced. Various mountings and chassis may adapt the unit to its many applications. Attachment to a wall oxygen outlet or oxygen tank, placement on a shelf or bedside table, use in specialized life-support systems or portable resuscitation kits are all within the device's capabilities.

**Performance**

The performance characteristics of a production unit (fig. 1) of this aspirator (Vaculette) were determined using a mercury manometer, a calibrated American Gas Meter Company Model 802 totaling flowmeter, and a stopwatch. Values (table 1) represent the average of ten trials. Comparative performances of other aspirators were investigated with the same instrumentation and conditions. All aspirators were new as supplied by the manufacturers.

<p>| Table 1. Comparison of New Gas-powered Aspirator with Conventional Electric Rotary, Foot-powered and Gas-powered Aspirators |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|</p>
<table>
<thead>
<tr>
<th>Maximum Vacuum</th>
<th>Free Air Flow through No. 16 FR Rubber Catheter</th>
<th>Aspiration Time for 100 ml Uniform Falsch Test Medium through No. 16 FR Rubber Catheter</th>
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</thead>
<tbody>
<tr>
<td>Vaculette Sorenson 1/10th h.p. Electric Rotary Aspirator</td>
<td>27 in/Hg</td>
<td>17.1/min</td>
</tr>
<tr>
<td>Ambu Foot-powered aspirator</td>
<td>28 in/Hg</td>
<td>14.3</td>
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<tr>
<td>Emerson Venturi on Resuscitator</td>
<td>10.6</td>
<td>Unsatisfactory</td>
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<tr>
<td>Stephenson</td>
<td>7.6 in/Hg</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>6.2 in/Hg</td>
<td>11.0</td>
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This new self-contained portable suction device exceeds the degree of vacuum attained by available foot pumps and venturis and approximates that attained by electric rotary types. Free air flow rate and ability to suction a viscid test medium is superior. Using the factory-provided collection jars, time required to attain an adequate clinical level of vacuum is less in the device described than in the electric rotary type (fig. 2).

While air ejectors have been used for suction devices for many years, they have never been able to attain the vacuum forces of electric rotary pumps. Within the past few years, increased understanding of fluid dynamics has elevated the state of the art in design of such devices. It is now possible to build devices which surpass the operating performance of electric aspirators. In addition to increased portability and freedom from power lines or vehicular electrical systems, air ejectors have no moving parts, are virtually maintenance-free, and require no lubrication. There is no inherent electrical hazard with danger of inadvertent ground paths.

In addition, this device may possess a significant physiologic advantage over electric or gas-powered suction devices which are turned on prior to insertion of the catheter. All deep suction results in negative pressure in the lungs. The degree of negative pressure created and the probability that resultant atelectasis or decreased intrathoracic pressure will result in increased systemic venous return and dilation of the vena cava and right heart depend on the suction created, the size of the catheter with respect to the tracheal diameter, and related factors. Radiographic demonstrations of this phenomena during suction have been made and reductions in arterial oxygen saturation during suction are also well established. It is clearly advantageous that suction does not exist before the intended moment of actual aspiration or during withdrawal of the catheter. Some suction exists at the catheter tip even though the T or Y junction of an electrical- or gas-powered suction apparatus may be open to the atmosphere. The operator might avoid activating the suction machine until the catheter is in position. However, many off-on switches cannot easily be reached by the person manipulating the catheter, and it is often difficult to compress and block many rubber or plastic catheters completely while positioning them. The combination of a trigger switch to energize the suction apparatus and modulate vacuum with the short time needed to achieve maximum vacuum may minimize undesirable intrapulmonary and intrathoracic negative pressures and their potential consequences in this new suction unit.

REFERENCES